Environmentally Friendly Coating Systems for Department of Defense Applications

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PPG Industries, Inc.

U.S. Army Corrosion Summit
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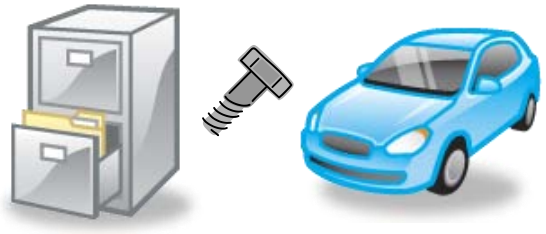
Evaluation of New Technologies

Commercial Coatings and Pretreatments



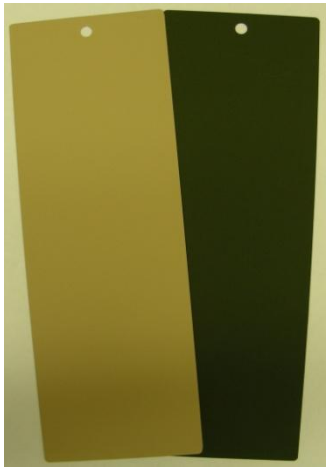
Department of Defense Needs

Programs

E-Coat for Munitions Modernization

Environmentally Friendly Zirconium Oxide Pretreatment

http://www.theodoregray.com/PeriodicTable/



SERDP WP-1676

E-Coat for Munitions Modernization

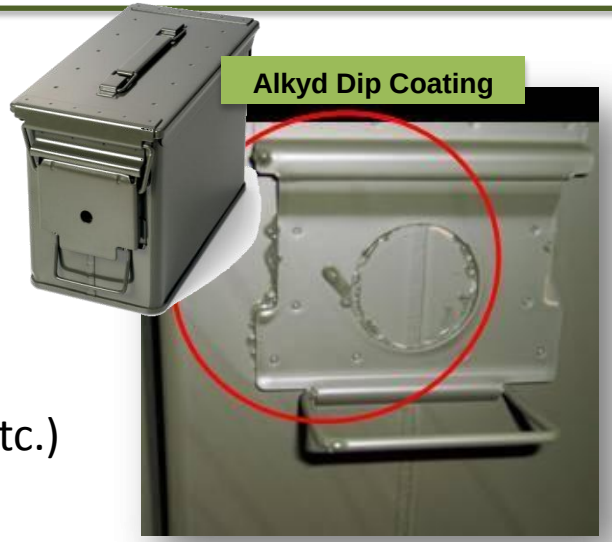
ARDEC Personnel
Jules Senske
Dan Schmidt
Don Skelton

http://www.theodoregray.com/PeriodicTable/

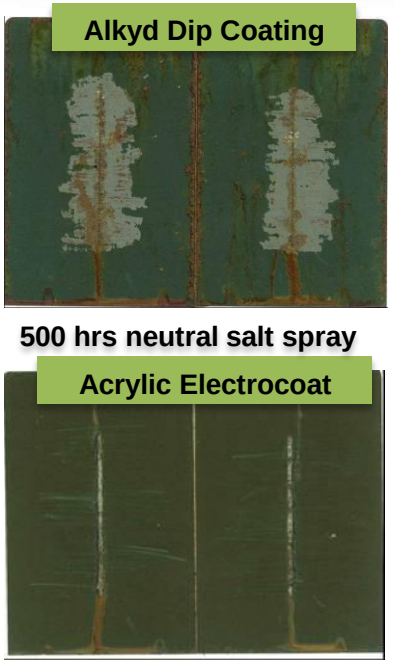
- "Electrocoat for Munitions Modernization"
  - Jules Senske, U.S. ARMY Corrosion Summit, 13 February 2008
- Coatings for munitions modernization
  - Project originally targeted acrylic electrocoat development
  - Expanded to powder coatings and other environmentally friendly treatments for munitions applications

Coatings for Munitions Modernization

- Current commercial munitions coatings
  - Alkyd Enamels (Mil-E-52891, Mil-DTL-11195)
  - Applied by spray or dip process
  - Salt-spray resistance requirement, 150 hrs
  - Possible aesthetic drawbacks (runs, drips, sags, etc.)



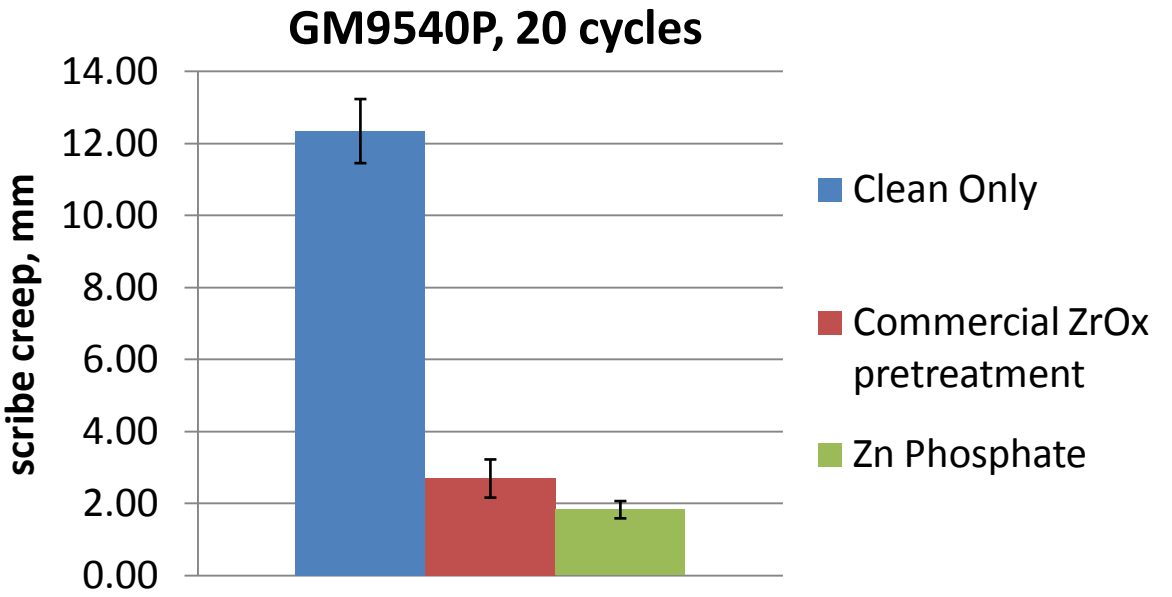
- Coatings for munitions modernization
  - Acrylic electrocoat and polyurethane powder
  - Higher work efficiency/simplified process
  - Durability > 750 WOM
  - Salt-spray resistance > 400 hrs
  - High transfer efficiency (approach 95-100%)
  - Low or no VOC
  - Widely used industrially



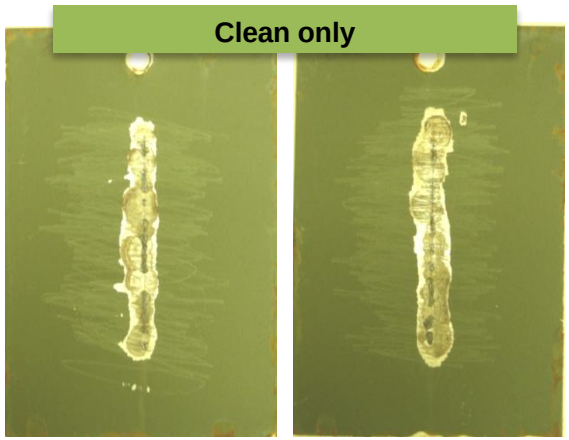
Coatings for Munitions Modernization (Systems Approach)

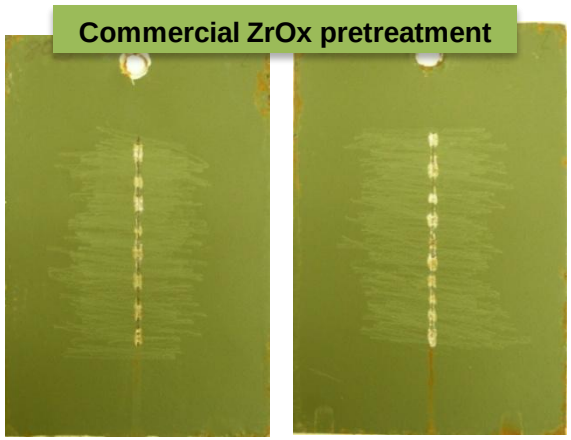
- Development of complementary coating systems for munitions applications
  - Opportunity to evaluate E-Coat and powder on munitions substrates
  - Systems approach for asset protection and enhancement
  - Aluminum, magnesium, and titanium
  - Stainless steel and high-strength steel (armor applications)

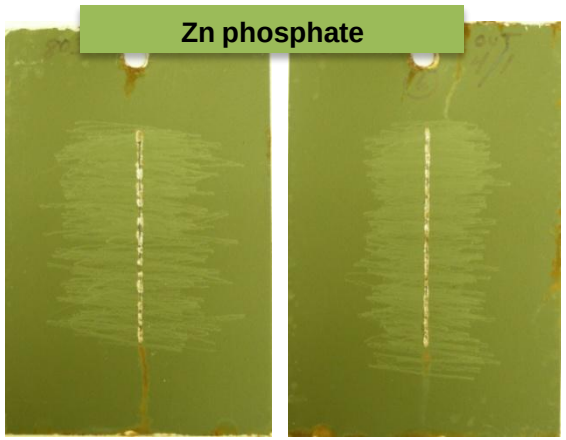
Systems Approach (Commercial Pretreatments with Powder Coating)



- Cold-rolled steel
- 2 mil Polyurethane powder coating
- Pretreated samples had < 1/4” scribe creep after 20 cycles GM9540P







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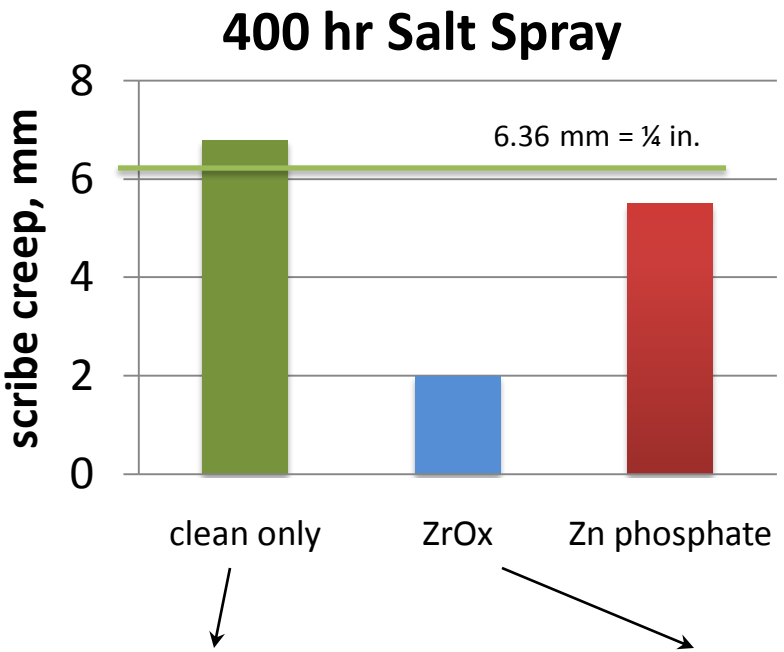
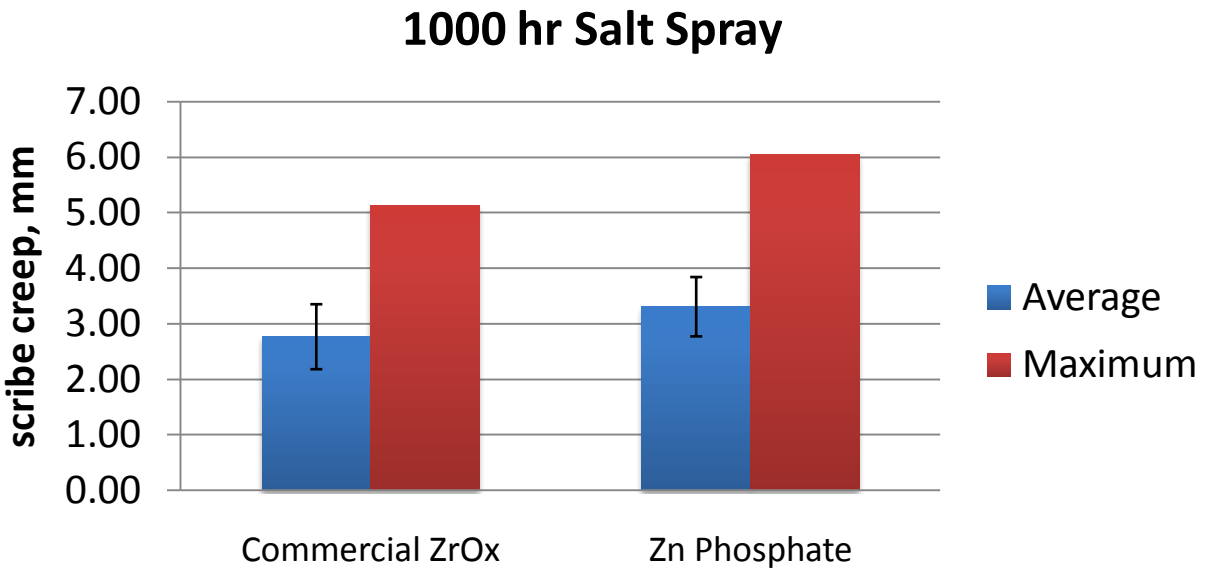
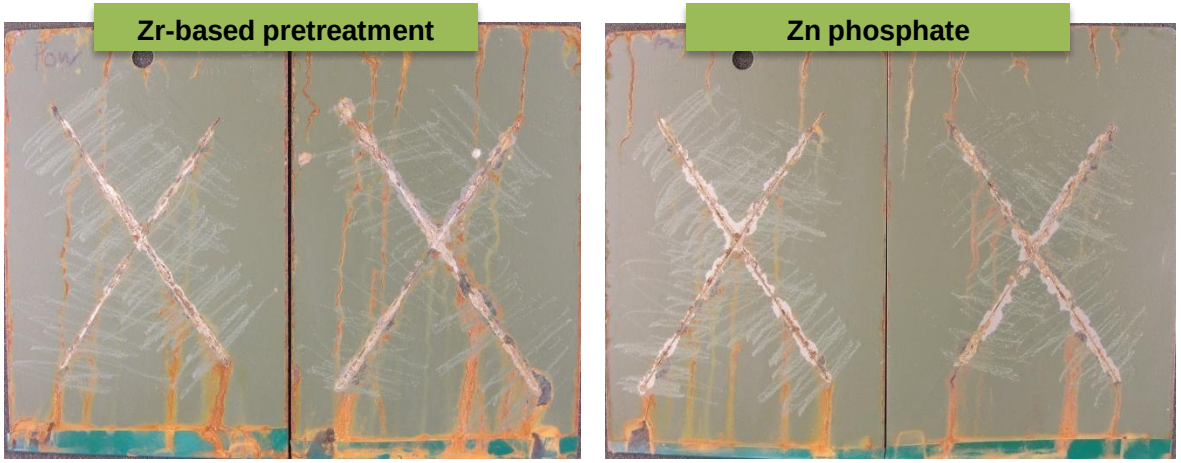


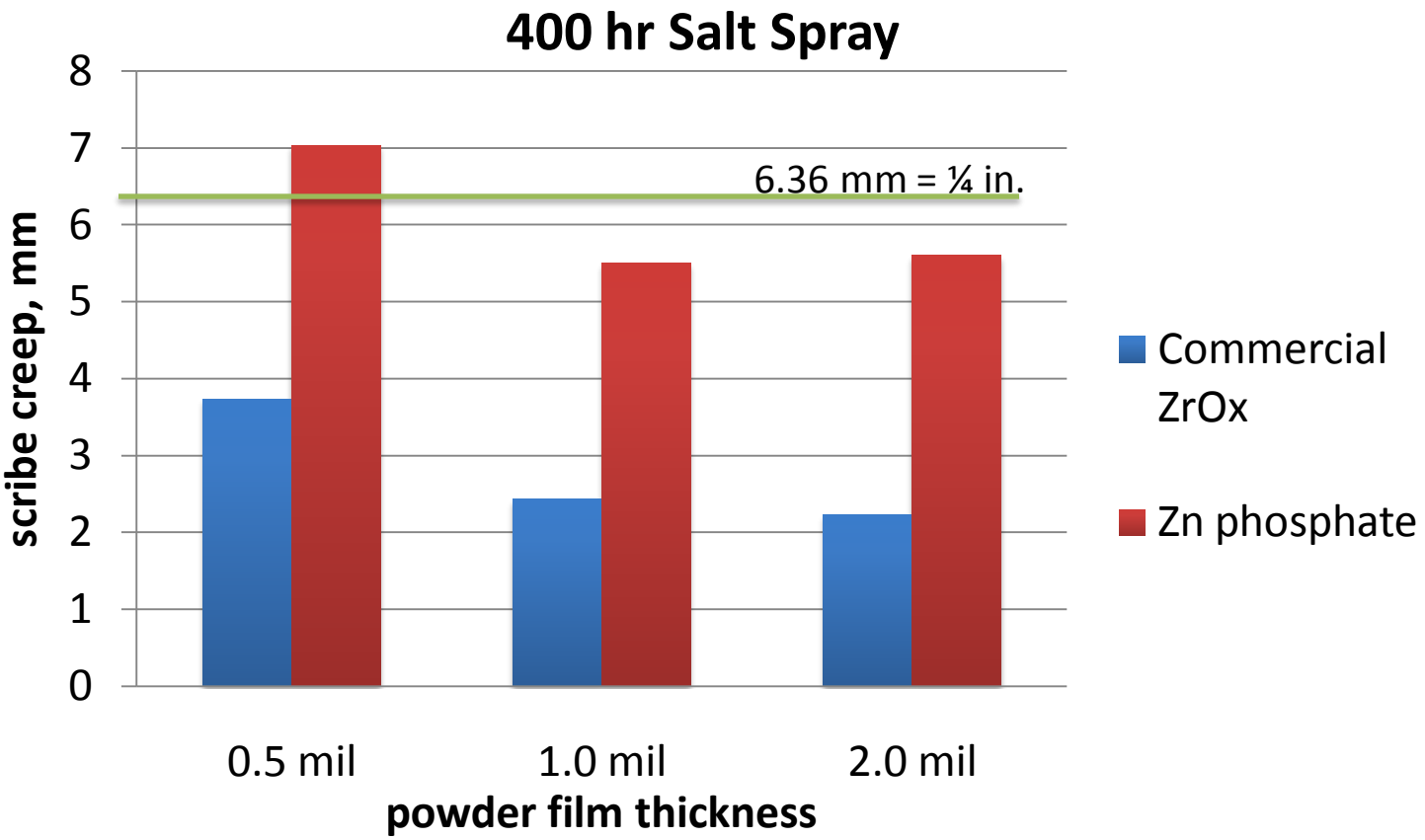
- Cold-rolled steel
- 2 mil Polyurethane powder coating
- Pretreated samples had < 1/4" scribe creep after 400 Salt-Spray

Systems Approach (Commercial Pretreatments with Powder Coating)



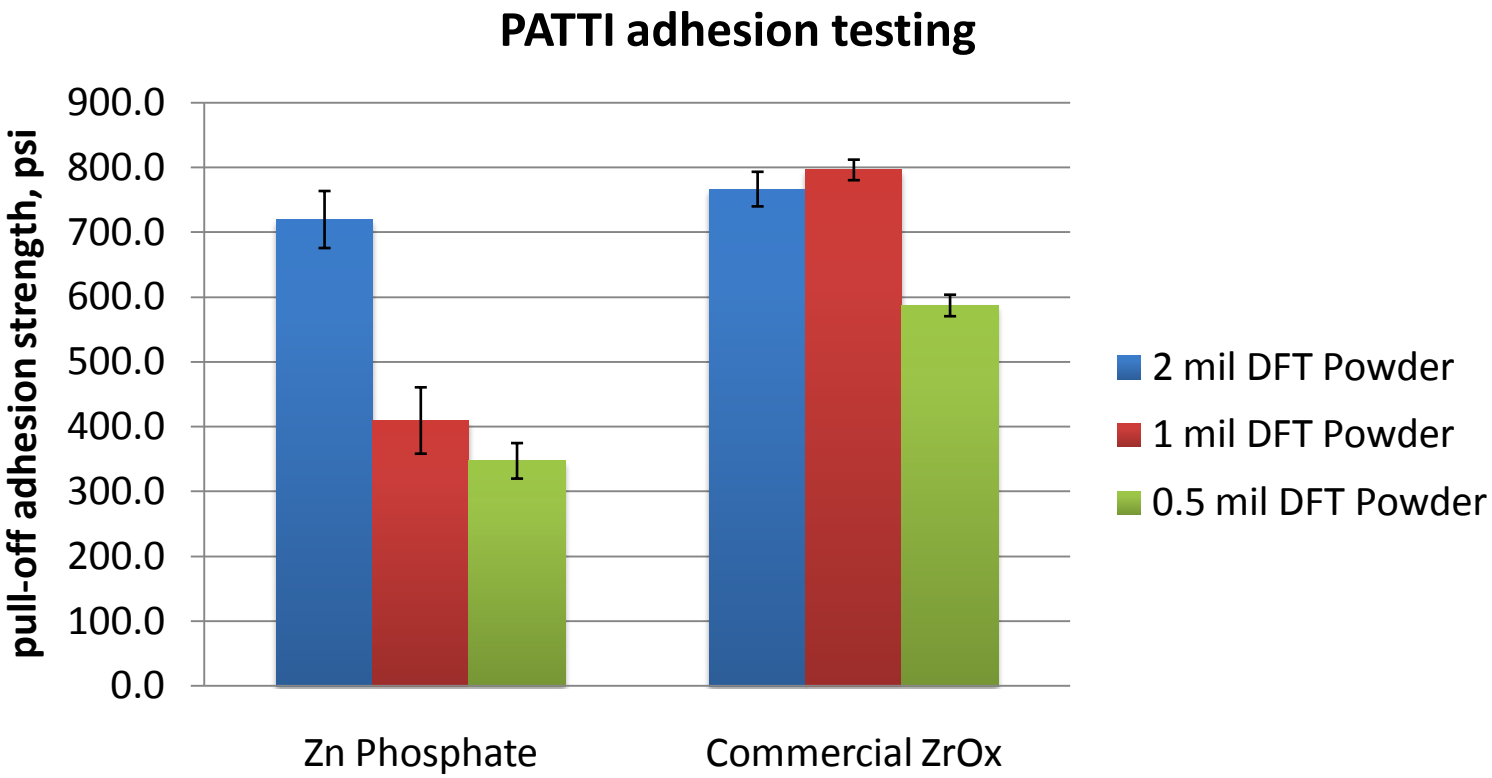


Systems Approach (Commercial Pretreatments with Powder Coating)



- 2 mil film build specification for polyurethane powder coatings
- ZrOx outperforms commercial Zn Phosphate
- Scribe creep specification met at all film thicknesses for ZrOx

Systems Approach (Commercial Pretreatments with Powder Coating)



- 2 mil film build specification for polyurethane powder coatings
- Better adhesion at all coating thicknesses for the ZrOx pretreatment

Systems Approach (Commercial Pretreatments with Powder Coating)

- Conclusions
  - Polyurethane powder/commercial pretreatment coating systems perform well in the testing outlined in Mil-E-52891 and Mil-DTL-11195, with several added environmental benefits over alkyd systems.
  - The powder/commercial zirconium pretreatment system provides performance superior to Zn phosphate, in adhesion and corrosion testing (ASTM B117 and GM9540P), at lower applied powder thickness.

- Path forward
  - Pretreatment systems for Ti, Mg, and Al alloys
  - Study the electrocoat system with commercial ZrOx pretreatments

Environmentally Friendly Zirconium Oxide Pretreatment

SERDP WP-1676

<u>ARL Personnel</u>
John Escarsega
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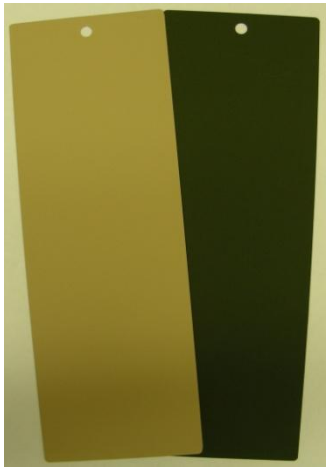
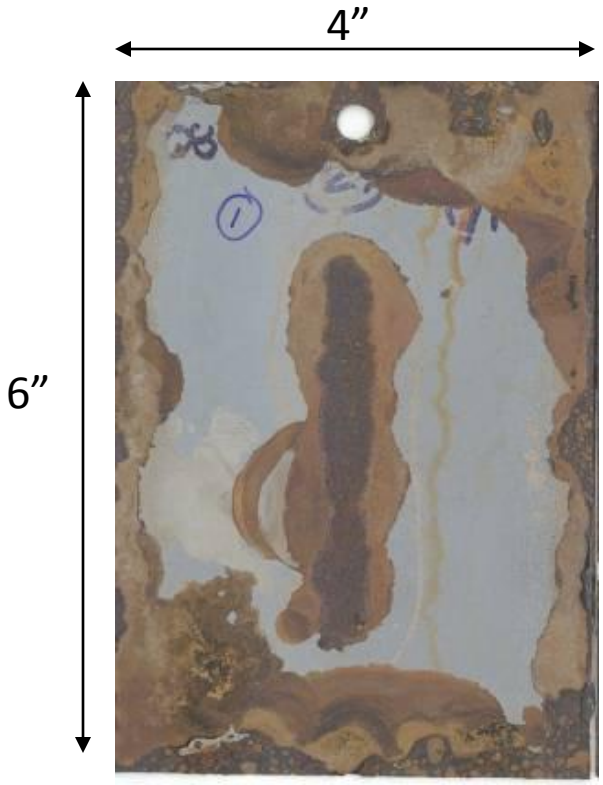


Technical Background

Do We Need Pretreatment?



No pretreatment

Zinc phosphate pretreatment

Electrocoated steel panels after GM 9540 cyclic corrosion testing

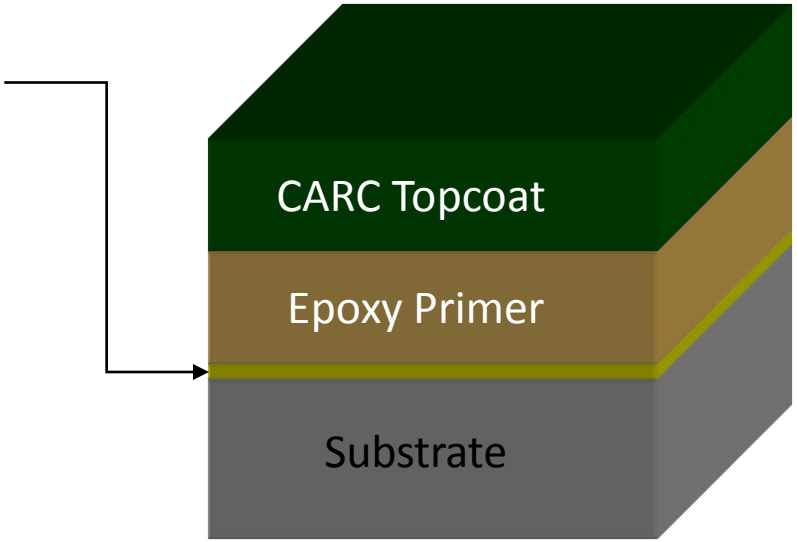
Environmentally Friendly Zirconium Oxide Pretreatment

Environmental/Health Impact

- DoD Wash Primer systems
  - 7.1% zinc chromate
  - 6.5 lb/gal of VOCs
- Yearly est. usage of 21,000 gal
  - 12,600 lb of zinc chromate
  - 35,700 gal of package/thinner solvents
- Environmental concerns and EPA regulatory issues associated with solvent emissions
- Worker safety and OSHA compliance issues related to the presence of regulated metals

Environmentally Friendly Zirconium Oxide Pretreatment

Wash Primer/Pretreatment



- Chemical Agent Resistant Coating (CARC) specification, MIL-C-53072, requires metal surfaces be treated to improve coating adhesion and corrosion resistance

- Zinc phosphate pretreatment required for Original Equipment Manufacturers

- Hexavalent Chrome (Cr^{6+}) containing wash primer required for Depot and Repair operations

SERDP 1676 Project Objective

- Develop an environmentally friendly pretreatment system for multi-material DoD applications
  - Free of hexavalent chromium (Cr^{6+})
  - No volatile hazardous air pollutants (HAPs)
  - Ease of application using existing infrastructure
  - Equal or better corrosion performance to current (Cr^{6+}) wash primers
  - Broad substrate/topcoat compatibility
  - Cost effective

Zirconium-Based Pretreatments

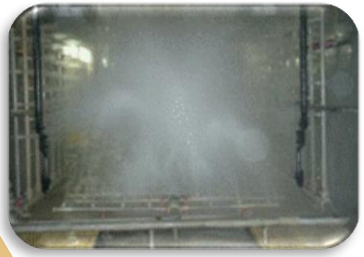
- Commercial Zirconium-Based Pretreatment
  - No regulated metals in pretreatment
  - Reduced energy cost for pretreatment application
  - Reduced water consumption for pretreatment application
  - Reduced pretreatment waste
  - No HAPS or VOC in pretreatment system

- Do commercial zirconium-based immersion pretreatments meet DoD specifications?
  - Confirm/determine that existing formulas meet DoD standards
  - Modify to meet DoD needs as necessary
  - Early experiments suggest Automotive OEM formula may not be directly applicable to DoD substrates/coating systems

Environmentally Friendly Zirconium Oxide Pretreatment

Task 1: OEM Pretreatment Development

immersion-applied ZrOx



spray-applied ZrOx

Task 3: Repair Pretreatment Development

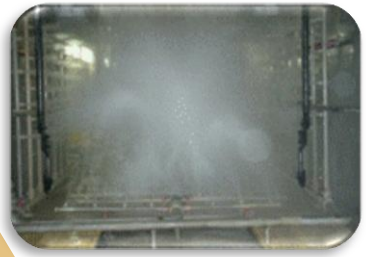
- Sanding
- Spray-Gun applied
- Wand applied
- Wipe-on

Task 2: Depot Pretreatment Development

Environmentally Friendly Zirconium Oxide Pretreatment

Task 1: OEM Pretreatment Development

immersion-applied ZrOx



spray-applied ZrOx

- Evaluate commercial immersion formulae with DoD substrates and coatings - reformulate as needed (Mil-Spec testing at ARL).
- Investigate and optimize lab prototype formula with a range of spray application conditions (Mil-Spec testing at ARL).

Environmentally Friendly Zirconium Oxide Pretreatment

- Visit DoD depot facilities to benchmark application process/conditions
- Determine compatibility of OEM spray formula with depot equipment.
- Characterization and limited Mil-Spec testing
- Formula optimization
- Comprehensive Mil-Spec testing

Task 2: Depot Pretreatment Development

Environmentally Friendly Zirconium Oxide Pretreatment

- Surface characterization.
- Evaluate optimized ZrOx spray formulation
- Limited Mil-Spec testing
- Reformulate
- Characterize
- Comprehensive Mil-Spec testing

Task 3: Repair Pretreatment Development

- Sanding
- Spray-Gun applied
- Wand applied
- Wipe-on

Acknowledgements

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Jim Poole
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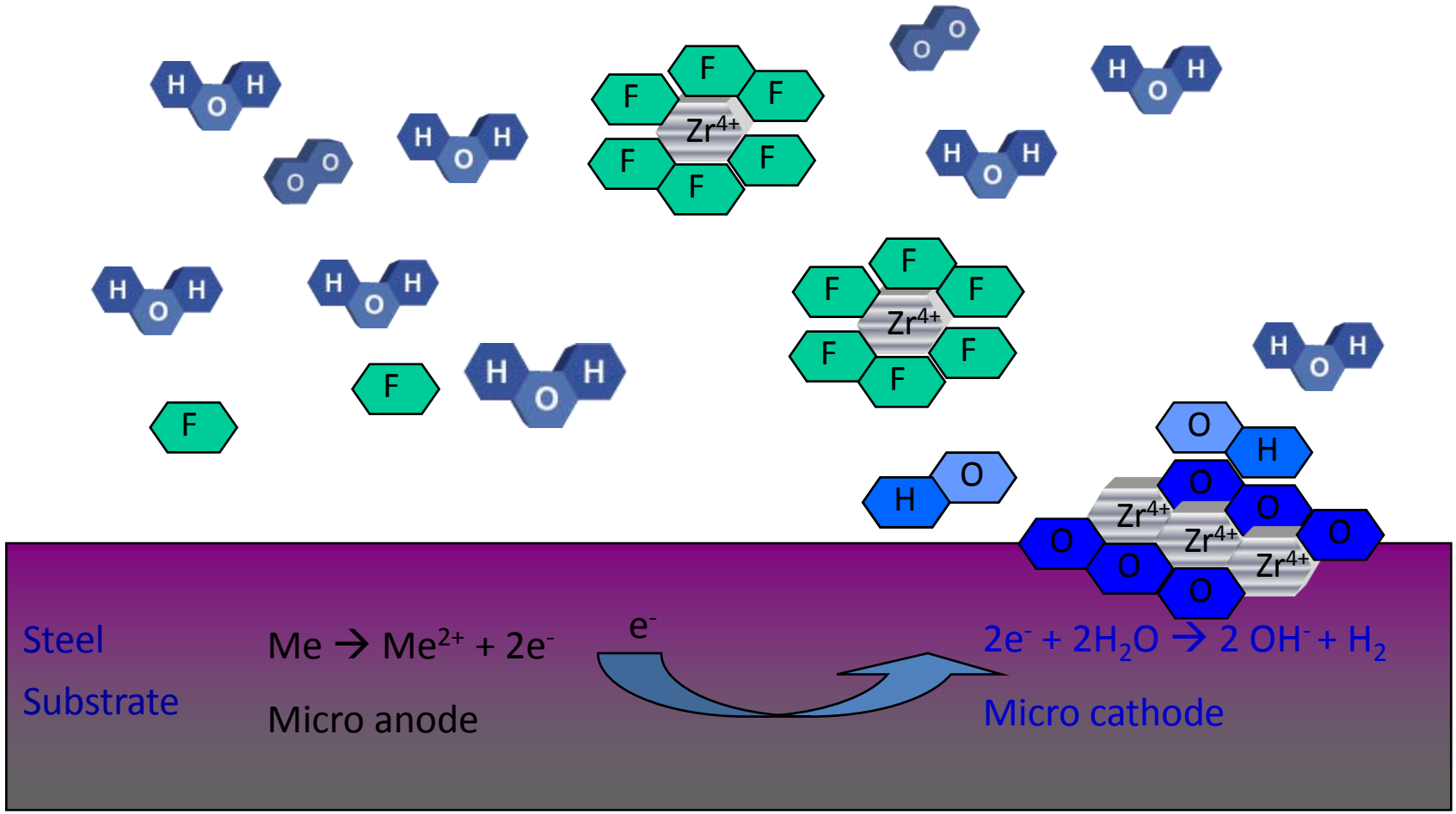
Zirconium-Based Pretreatment



Coating thickness: 20-200 nm.